

ORGANIC CHEMISTRY

10.3 – ALKENES

IB Chemistry

Topic 10 – Organic

Resource:

Brown, Ford, HL Chem



10.3 – Alkene Reactions

- 10.3.1 Describe, using equations, the reactions of alkenes with hydrogen and halogens. (2)
- 10.3.2 Describe, using equations, the reactions of symmetrical alkenes with hydrogen halides and water. (2)
- 10.3.3 Distinguish between alkanes and alkenes using bromine water. (2)
- 10.3.4 Outline the polymerization of alkenes. (2)
- 10.3.5 Outline the economic importance of the reactions of alkenes. (2)



Types of Reactant

Saturated

- Compounds which contain only single bonds
- For example: alkanes

Unsaturated

- Compounds which contain double or triple bonds
- For example: alkenes, arenes

Aliphatics

- Compounds which do not contain a benzene ring; may be saturated or unsaturated
- For example: alkanes, alkenes

Arenes

- Compounds which contain a benzene ring; they are all unsaturated compounds
- For example: benzene, phenol

Electrophile (electron-seeking)

- An electron-deficient species which is therefore attracted to parts of the molecules which are electron rich
- Electrophiles are positive ions or have a partial positive charge
- For example: NO_2^+ , H^+ , $\text{Br}^{\delta+}$

Nucleophile (nucleus-seeking)

- An electron-rich species which is therefore attracted to parts of molecules which are electron deficient
- Nucleophiles have a lone pair of electrons and may also have a negative charge
- For example: Cl^- , OH^- , NH_3



Types of Reaction

Addition	<ul style="list-style-type: none">•Occurs when two reactants combine to form a single product•Characteristic of unsaturated compounds•For example: $\text{CH}_4 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2$
Substitution	<ul style="list-style-type: none">•Occurs when one atom or group of atoms in a compound is replaced by a different atom or group•Characteristic of saturated compounds and aromatic compounds•For example: $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$
Elimination	<ul style="list-style-type: none">•Occurs when a small molecule is lost from a larger compound•Usually results in the formation of a double or triple bond•When the molecule eliminated is H_2O, the reaction is dehydration•For example: $\text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$
Addition-Elimination	<ul style="list-style-type: none">•Occurs when two reactants join together (addition) and in the process a small molecule such as H_2O, HCl or NH_3 is lost (elimination)•Reaction occurs between a functional group in each reactant•Also called condensation reaction•For example: $\text{RNH}_2 + \text{R}'\text{COOH} \rightarrow \text{R}'\text{CONHR} + \text{H}_2\text{O}$



Types of Bond Breaking (bond fission)

Homolytic fission

- When a covalent bond breaks by splitting the shared pair of electrons between the two products
- Produces two free radicals each with an unpaired electron

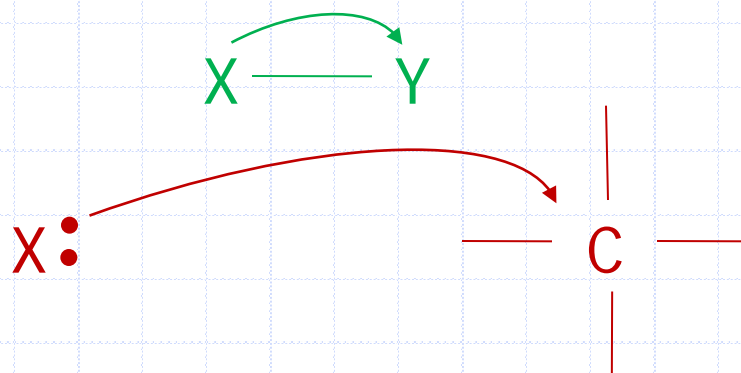
Heterolytic fission

- When a covalent bond breaks which both the shared electrons going to one of the products
- Produces two oppositely charged ions



Convention for depicting organic reaction mechanisms

- Showing movement of electrons
 - Within bonds and between reactants
- The curly arrow is used
 - Drawn from the site electron availability to the site of electron deficiency.



Represents e⁻ pair being pulled towards Y so Y becomes δ^- and X becomes δ^+

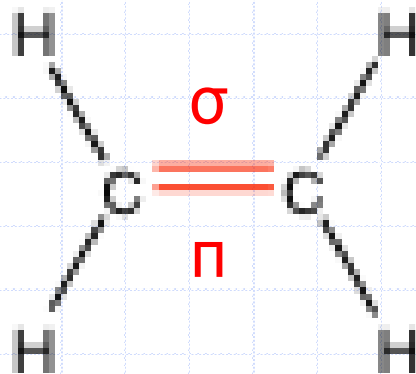
Nucleophile X attracted to e⁻ deficient C

The double-headed arrow represents the motion of an electron pair. When electrons are fully transferred through several steps they are known as the "leaving group."



Alkenes

- General formula is C_nH_{2n}
- Alkenes are **unsaturated hydrocarbons** containing a carbon-carbon double bond



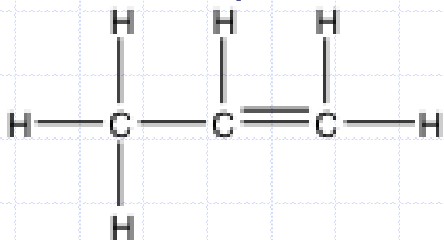
- Double bond is made of two types of bonds, one sigma σ , and one pi π . Carbon atoms are sp^2 hybridized, forming a trigonal planar arrangement of groups with 120° angles



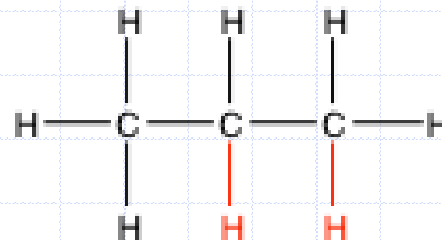
Alkene addition with Hydrogen

10.3.1 Describe, using equations, the reactions of alkenes with hydrogen and halogens. (2)

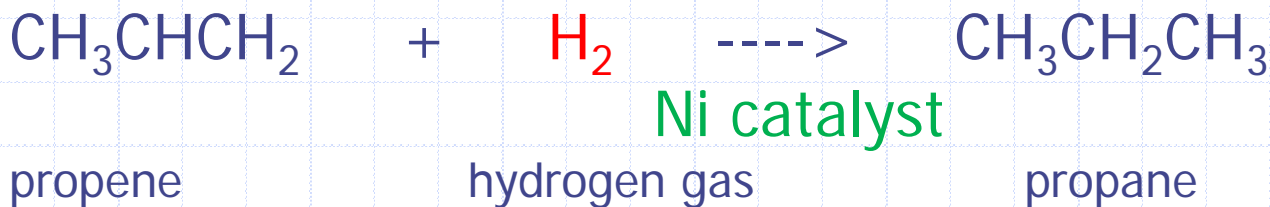
- With the presence of a nickel catalyst at about 150°C, for example



prop-1-ene



propane

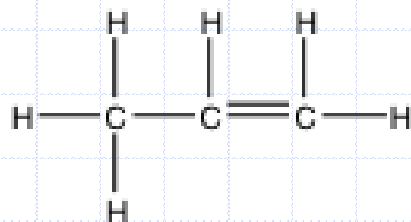


- ♦ Known as **hydrogenation**, used in the margarine industry to convert oils containing unsaturated hydrocarbon chains into more stable saturated compounds with higher melting points

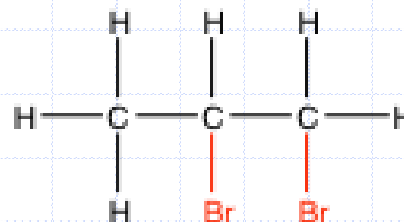


Alkene addition with halogens

- Halogens react with alkenes to produce dihalogeno compounds.
- Occur quickly at room temperature and are accompanied by the loss of color of the reacting compound.



prop-1-ene



1,2-dibromopropane



propene

+



bromine gas

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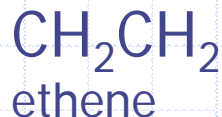
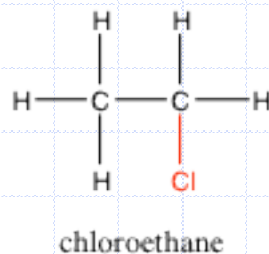
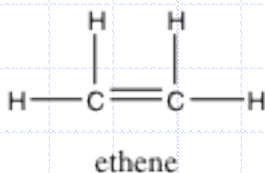
1,2-dibromopropane



Alkene addition with hydrogen halides

10.3.2 Describe, using equations, the reactions of symmetrical alkenes with hydrogen halides and water. (2)

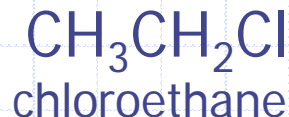
- Hydrogen halides (HCl, HBr, etc) react with alkenes to produce hydrogenalkanes.
- Take place rapidly in solution at room temperature.
- All halogens are able to react in this manner, but the reactivity is in the order $\text{HI} > \text{HBr} > \text{HCl}$, per the decreasing strength of the hydrogen halide bond.



+

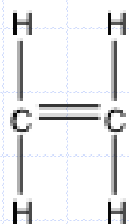


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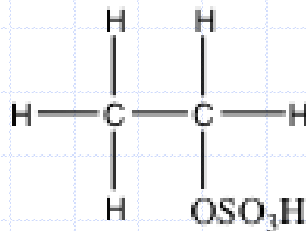


Alkene addition with water

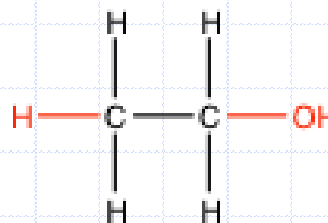
- The reaction with water is known as hydration and converts the alkene into an alcohol.
- Use of concentrated sulfuric acid as catalyst.
- Involves intermediate in which H^+ and HSO_4^- ions are added across the double bond.



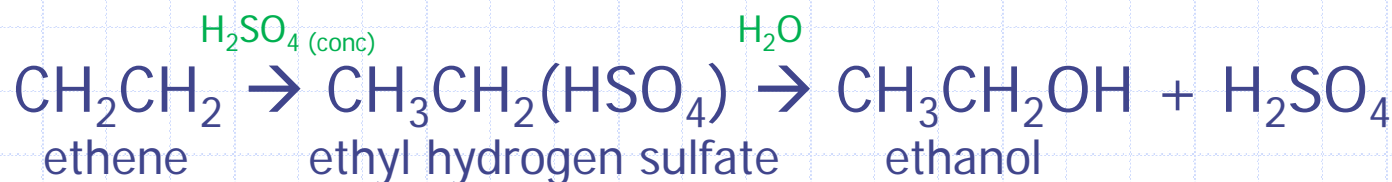
ethene



ethyl hydrogen sulfate



ethanol



Distinguish between Alkanes and Alkenes

10.3.3 Distinguish between alkanes and alkenes using bromine water. (2)

- Alkenes readily undergo addition reactions, alkanes will not (and only in UV light)
- Shake separate samples of alkanes and alkenes with bromine water at room temperature, red-brown color of bromine water is decolorized by the alkene (but not the alkane)
- Color of a burned flame. Alkenes have high ratio of C:H and leave unburned carbon. Results in a smokier, dirtier flame from alkenes.



Polymerization of alkenes

10.3.4 Outline the polymerization of alkenes. (2)

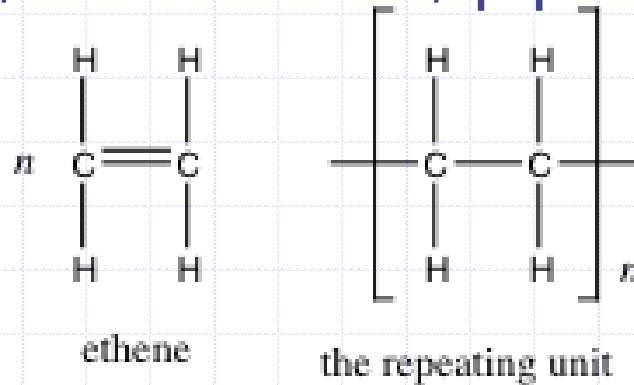
- Since alkenes readily undergo addition reactions by breaking their double bonds, they can be joined together to produce long chains known as **polymers**. The alkene is known as the **monomer**.
- Example:
 - Ethene polymerizes to form polyethene, commonly known as **polythene**. First discovered by accident in 1935, was used extensively as an insulator in the WWII.



Repeating Units for Polymers

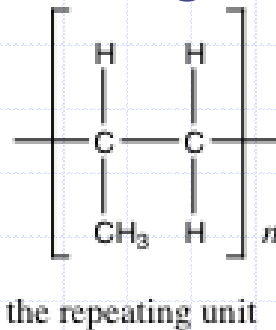
- Polythylene:

- Insulator, water tanks, piping..



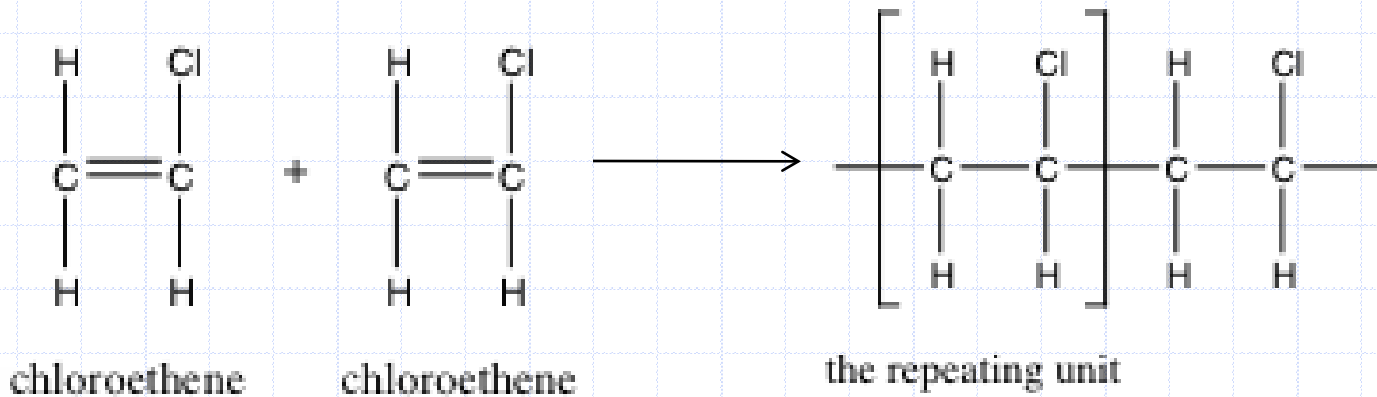
- Polypropylene:

- Manufacture clothing, especially thermal wear



PVC (poly vinyl chloride)

- Polychloroethane (PVC) is widely used in construction materials, packaging, electrical cable sheathing, etc.
- Synthesis is associated with toxic byproducts known as **dioxins**, which are linked to reproductive disorders and a variety of cancers.



Alkenes: Resources, Money, Time

10.3.5 Outline the economic importance of the reactions of alkenes. (2)

- Alkenes readily undergo addition reactions and are used as starting materials for many important industrial chemicals.
- On the next slide you will find a flow chart for the production of compounds from ethene



Catalytic Cracking of ethene

Ethene
(from
cracking
)

React with steam

ethanol

polymerize

Poly(ethene)
(polythene)

React with chlorine

Chloroethene
(vinylchloride)

Ethanol

Poly(chloroethene)
(PVC)

React with benzene

Phenylethene
(styrene)

Ethanol

Poly(phenylethene)
(polystyrene)

